KNMI HUMIDITY SENSOR TEST

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Abstract

In order to find a suitable instrument to replace the current humidity sensor used in KNMI's measurement network, a project for testing has been set up. Following market research, four likely candidates have been found. The test has two clear phases. First, all the instruments are thoroughly tested in the laboratory. In a climate chamber, measurements of humidity are taken for 9 values of humidity and for a range of temperatures. Also, response times are measured for the sensors. The second phase of the test consists of field tests. The purpose of these is to find the effects of the outdoor environment on the sensors, and to have an indication of future calibration intervals. These tests will take one year. After the field tests, the sensors will again be thoroughly tested in the climate chamber. This paper shows the progress of this work.

Introduction

At present, KNMI has Vaisala HMP233 humidity sensors in use in the measurement network in the Netherlands. Although they have largely worked well, there is still room for improvement. The sensors response time is slow in a high humidity environment, and the calibration interval is relatively short. This, combined with the fact that the HMP233 will not be produced for much longer, has resulted in a search for a replacement for the current sensor. The new sensor needs to meet the WMO requirements along with some additional KNMI requirements.

Market research

In order to select sensors for testing, a market research was performed. A number of sensor properties were considered in making the selection. In the first place, the sensors need to meet the WMO performance requirements, shown in the next Table [1].

Requirement	*Wet-bulb temperature*	*Relative Humidity*	*Dew-point temperature*
Range	-10 to +35 °C	5 – 100 %	At least 50 K in the range –60 – +35 °C
Target accuracy[1]	± 0.1 K high RH ± 0.2 K mid RH	± 1 % high RH ± 5 % mid RH	± 0.1 K high RH ± 0.5 K mid RH
Achievable observing accuracy[2]	± 0.2 K	± 3 – 5 %	± 0.5 K
Reporting code resolution	± 0.1 K	± 1 %	± 0.1 K
Sensor time constant[3]	20 s	40 s	20 s

Output averaging time[4]	60 s	60 s	60 s

Table 1. WMO performance requirements for surface humidity measurements. [1]: 2 standard deviations. [2]: ideal case, difficult to achieve in practice. [3]: 1/e after a step change. For climatological use: 60 s.[4]: For climatological use: 3 minutes.

KNMI also has additional requirements such as: an absolute accuracy (in RH) of 3.5 %RH, digital output, digital calibration possible, a long calibration interval (*i.e.* stability requirements), easily interchangeable sensors and price.

The sensors selected based on these criteria are shown in Table 2.

Sensor	*Manufacturer*	*Comment*
HMT337	Vaisala	successor to the HMP243, heated
HMT317	Vaisala	a simplified version of the HMT317, also heated
HygroClip	Rotronic	
Hygroclip + M33	Rotronic	M33 gives derived products, allows networking and digital interface
EE31	EplusE	

Table 2.

All the sensors are capacitive sensors and most can be (or are) combined with a temperature sensor. Some of the sensors also give derived products. The sensor accuracies are comparable on paper, as are the time constants. The tests will show if this is also the case under unfavourable conditions (*e.g.* at high humidity).

Laboratory tests

Sensors

The sensors tested in the laboratories are the selected sensors from Table 2, plus the "old" sensors HMP233 and HMP243 in order to make a good comparison with the current situation. Since, during the field tests, the Thygan dewpoint mirror from MeteoLabor will also be used, this sensor is also tested in the laboratory. Apart from the Thygan, there are 3 or 4 sensors for each type, making a total of 21 sensors to be tested. All sensors are used with their factory calibration.

Set-up

The sensors are tested in a climate chamber at KNMI. This chamber is humidity and temperature controlled and manufactured by Weiss. The humidity of the climate chamber is measured with a Michell S4000 dew-point mirror, and the temperature with Pt500 element. These measurements are accurate to within 0.13 °C (T_d) and 0.03 °C (T), respectively.

The sensors are placed in the centre of the climate chamber. Because of the limited space and connections available, only 6 sensors can be tested at one time. This means that 4 series of measurements are needed. The sensors for each series are selected such that most types are present.

Tests

Two types of tests are performed. The first type tests the accuracy of the sensors for a range of temperature and humidity. The second type tests the time response time of the sensors.

Accuracy

In order to test the accuracy of the sensors, their response are measured for a number of temperatures and humidities. The humidities used are roughly: 17, 27, 37, 47, 57, 67, 77, 87 and 97 %RH. All these values are measured at different temperatures: 2 or 3 temperatures below 0 °C (-15, -10, -5 °C) and at temperatures of 0, 10, 20 and 30 °C.

For the tests, the chamber is set at the required values and the sensors are allowed to stabilize. Then the measurement is taken and the chamber is set at the next value.

Response time

For the time response, two methods are used. The first one is a coarse one to get an upper limit for the response time. And the second one is a more accurate measurement.
In the first measurement, the climate chamber is set to the exact temperature of the room it is in, but at a higher humidity. Then the door of the chamber is opened and chamber is allowed to stabilize while the response of the sensors is recorded. This method will result in a combined response of the chamber and sensors, thus giving an upper limit to the time response of the sensors.
In the second method, the sensors are placed in a small box containing sillica gel, which is placed inside the climate chamber. The gel will cause the humidity inside the box to be lower than in the climate chamber. Then the sensors will be take out of the box, and the response measures. Because the box is much smaller than the climate chamber, the effect that is measured can be largely contributed to the time response of the sensor.

Results

Accuracy

An example of the results can be seen in Figure 1.

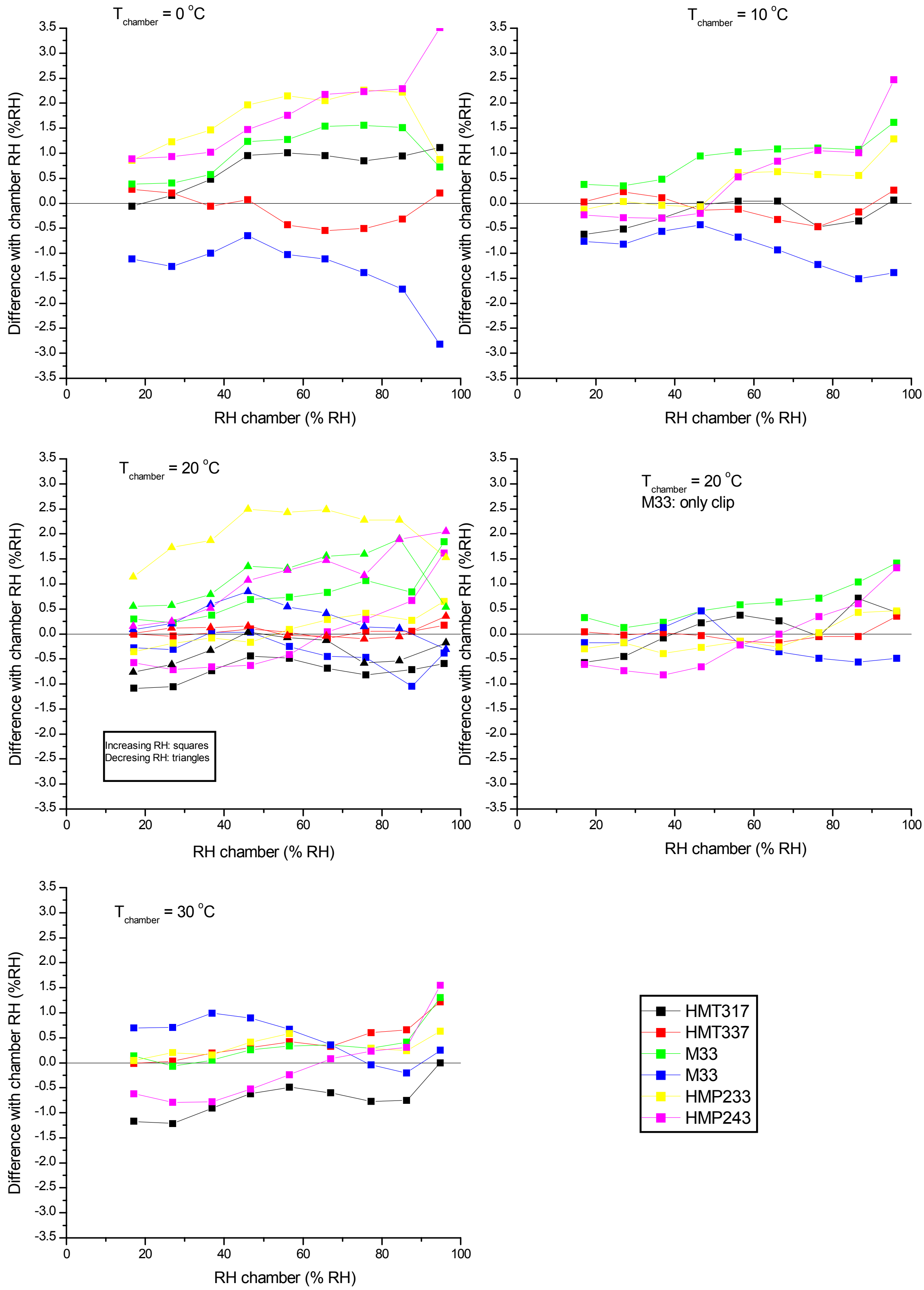

Figure 1. Results for temperatures from 0 – 30 C for the sensors indicated. On the y-axis the difference in Relative Humidity between the sensor and the climate chamber, on the x-axis the humidity of the climate chamber. "only clip" means that the Rotronic HygroClip was used without the M33.

Response time

An example of the response time measurements using the first method can be seen in the next figure. In the plots on the right, the protective filters were removed in order to see the effect of the different filters.

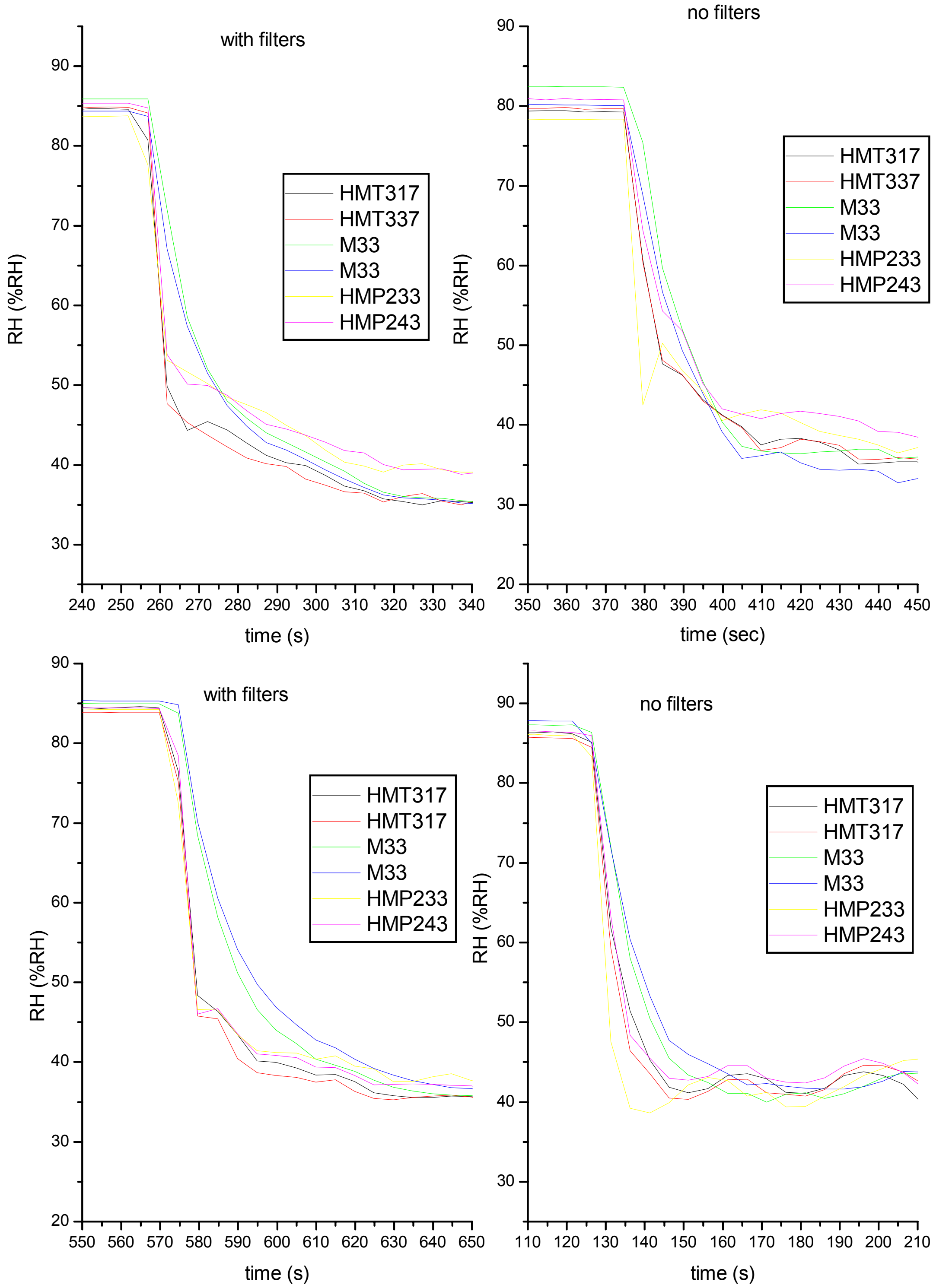

Figure 2. Response times measured using the first method (see text). T ≈ 25 °C.

Field tests

Set up

In the field tests, 2 locations are used. One in the centre of The Netherlands (De Bilt) and one near the North Sea coast (Vlissingen). The sensors are placed in the KNMI radiation screens (except the Thygan which has it's own screen). For both locations, at least 2 instruments of the same type are used. Additionally, in De Bilt the Thygan dewpoint mirror is used as a reference instrument, and the HMT 337 so-called "chemical purge" option is tested using an extra sensor.

Tests

The field tests consist of simply monitoring the response of the sensors to the outdoor environment. In order to keep track the sensors' stability, they are checked in the climate chamber once every month or 2 months. This check is a reduced version of the laboratory accuracy tests.

Results

Unfortunately, at the time of the writing of this paper, no field test results have been obtained yet. The first field tests are expected at the beginning of 2007. Please contact the author if you are interested in the results.

Discussion and conclusions

All the discussed results refer to the laboratory tests.

The accuracy results so far show that all sensors considered (except for the E+E sensors which are yet to be measured) are within the KNMI specifications. An example of these results can be seen in Figure 1. The real test will be of course whether the sensors will also be within specifications after a longer time outside, and under more difficult circumstances such as during and after 100 % relative humidity.

The response time measurements performed so far give an upper limit to the response times. These are approximately:

sensor	response with filter	response without filter
	(s)	(s)
HMT337	6	6
HMT317	6	6
HygroClip/M33	16	13

Since these are combined response times of the sensors and the climate chamber, no definite conclusions can be drawn from them. It does show, however, that the Rotronic sensors have longer response times than the two (heated) Vaisala sensors. However, in the current tests all sensors are within specifications. More detailed response measurements will be done later.

As this research is work in progress, no definite conclusions can be drawn yet.

References

1. Guide to Meteorological Instruments and Methods of Observations, 6^{th} edition, WMO-No. 8, 1996.